

Cumulative Effects of Fuel Management on Landscape-Scale Fire Behavior and Effects

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Mark A. Finney, Principal Investigator

USDA Forest Service, Missoula Fire Sciences Laboratory, Missoula, MT.

mfinney@fs.fed.us

Problem

Earlier works (Finney, 2001a, Finney, 2001b) showed that patterns of disconnected fuels treatment patches that overlap in the direction of maximum spread (head fire) are theoretically effective in changing overall forward fire spread rate. This line of research is commonly referred to by fuels practitioners as the “Finney Blocks” concept. This study builds on those earlier works to explore a practical application of the concept, namely in locating fuel treatments across the landscape.

This study addresses placement, size, and longevity of fuels treatments at a landscape scale. Determining where to place fuels treatments across the landscape, how big those treatments should be, and how often to repeat treatments have all proven difficult questions to answer for fuels specialists working in diverse landscapes. Trying to find where the biggest impact for the investment can be realized when planning fuels treatments is the key problem area that this study addresses.

Approach

The overall study was broken into 3 separate phases. The first phase entitled “A Computational Method for Optimizing Fuel Treatment Locations” focused on developing an optimization model for placing fuels treatments across diverse landscapes. The focal idea being on placing treatments where they would interrupt fire spread at those locations where fuels/weather/topography produce the fastest spread rates, thus reducing the overall risk from fire by reducing overall spread rates across the landscape.

The second phase is entitled “Simulation of long-term landscape-level fuel treatment effects on large wildfires.” This portion of the study employed the fuels treatment optimization model from phase one along with forest vegetation (FVS) and fire growth (Farsite) models to simulate fuel treatments and their resulting influence on fire behavior across large landscapes and over multiple decades. The scenarios compared were:

1. Vary the amount of treatment from 0% to 50% of the landscape
2. Vary maximum treatment size from 400 to 1600 meters/unit
3. Compare randomly placed vs optimized treatments patterns
4. Reserves of randomly selected areas in the proportion of 15% to 65% of the landscape
5. Fire simulations under moderate weather conditions (90th & 95th percentile) to test treatment performance designed at the extreme weather conditions (99th percentile)

The study areas ranged from between 100,000 acres to 135,000 acres and included the Blue Mountains in Oregon, Sanders County in Montana, and the Stanislaus National Forest in California. Simply put, the various fuel treatment options described above were placed across the simulation landscapes, then the forest vegetation simulator “grows” the vegetation over some prescribed time frame, some logic is applied to convert those outputs into fuels information, then the fire growth model is applied to determine how the various treatments performed in terms of modifying fire growth.

The third and final phase was entitled “An Overview of FlamMap Fire Modeling Capabilities” and describes the changes made to the FlamMap v 3.0 software that incorporates the new fuel treatment optimization capability. All the FlamMap v 3.0 capabilities are described, many of which were not directly related to this study, but this paper updates the newly added functionality for determining fuels treatment locations.

Project Findings

The key finding from the first phase of the project was that the fuel treatment optimization model was effective at reducing overall rates of spread across a diverse landscape. The key finding of the second phase is that when using fuel treatment prescriptions that involve thinning and prescribed burning, even optimal treatment arrangements (designed to disrupt the growth of large fires) require at least 10% to 20% of the landscape to be treated each decade. A second finding from phase two is that selective placement of treatment is far more effective than randomly arranged units, which for the same treatment prescriptions require about twice the rate to produce the same effectiveness. The results also show that the fuel treatment optimization tends to balance maintenance of previous units with treatment of new units. For example, with 20% landscape treatment, fewer than 5% of the units received 3 or more treatments in 5 decades with most being treated only once or twice and about 35% remaining untreated the entire planning period.

Application by Land Managers

The overall simulation system used in the case studies (Phase two) that were intended to determine the optimum placement and timing of fuels treatments across a large landscape are likely too complex for the journeyman fuels specialist to perform on their own. These case studies (Phase two) required a team of 3-5 experts with expert knowledge of fire modeling, stand development, fuels treatment prescriptions, and development and analysis of spatial-temporal data. The computing facilities required for the work also greatly exceed those of most land management facilities, thus the ability to “optimize” fuel treatments for specific landscapes using the techniques described in Phase two of this project is likely out of the realm of possibility for most units.

The incorporation of the fuel treatment optimization model in version 3.0 of FlamMap does make the results of the study accessible to managers for use on individual planning areas. The difference is the fire vegetation simulator is not available to “grow” the forest post treatment and continue to define “optimal” solutions, thus the optimization is performed only for a snap-shot in time and does not factor in treatment longevity and optimization patterns over a given time period.

The most obvious application for the applicable results (FlamMap fuels optimizer) is in strategic planning of fuels programs. This study indicates that for western fuel types, a fuels program may want to achieve treatment of 10% to 20% of the landscape in order to achieve a measurable disruption on fire growth. The optimization model also would indicate that repeat treatments within about a 50 year period is not as desirable as moving those treatment areas throughout the landscape.

This and several related studies also have application at the project level, especially in terms of providing a framework to evaluate fuels treatment options. Ager et. al. (2006a), introduces the Fireshed process within ArcGIS which can serve as a starting point for determining fuels treatment sizes and placement. This is a data intensive process and is likely best suited for large to very large project areas such as watershed or district/forest-wide assessments. Another work by Ager et. al. (2006b) uses a similar approach to this study by Finney, but it adds the concept of expected net value change by translating the outputs of the simulation into economic terms. Ager et. al. (2006b) uses a hypothetical landscape that includes potential losses to ecological and urban interface values as well as potential benefits to ecological values and unlike this work by Finney which focuses on minimizing fire spread across the landscape, Ager et. al. looks at the more pressing issue of focusing attention on those areas of the landscape that are most valuable.

This study along with others (Finney 2006, Finney 2001a, Finney 2001b, Finney 2004) are collectively applicable to supporting the idea of optimal placement of fuels treatments. For smaller project areas, these studies are applicable to the cumulative effects sections of a fuels specialists report when tying a specific project into the overall fuels program strategy. The “Finney Blocks” concept is well supported in these simulations as well as in case studies (Graham et. al 1999, Pollet and Omi 2002, Graham 2003).

One must be mindful however that this body of work does not consider spotting potential or resistance to control when determining optimal size and placement of fuels treatments. Fuels specialists should use caution when interpreting results of these simulations and consider whether spotting potential would be such that the modeled maximum treatment size is invalid.

Another questionable assumption is that risk from fire will be reduced by decreasing the rate at which fires travel across the landscape. This is a similar assumption to that made by Valdez & Dean (200?), who’s study was very similar in design to this one in that the measure of success for fuels treatments was to slow rates of spread across the landscape through targeted fuels treatments. The basic problem with this shared assumption is that fire tends to travel fastest in the lighter fuels (grasses, brush) where as it travels slowest in the heavier fuels (timber litter, slash). In terms of threat to values, practical experience and research (Cohen 2000) has shown that lighter fuels are less of a threat than heavier fuels when found adjacent to the values we wish to protect. Heavier fuels also produce higher intensities and longer durations (continue to burn over several burning periods), thus their resistance to human control are factors that should be considered when discussing risk. Lighter fuels while producing faster moving fires, also produce lower intensity fires that are shorter in duration, often lasting only a single burning period. Thus if our objective is to protect values at risk, the notion that slowing down fire spread across the landscape will result in better protection of values may be flawed.

The fire manager must also consider that these modeling schemes assume that no control efforts will influence the outcome, when we know for certain that we are likely going to maintain at least some level of firefighting capability locally and nationally. If the analyst applies the fire suppression principle of “Speed and Force”, we need to consider rate of spread and intensity together in order to quantify whether the Speed and Force of a modeled fire scenario exceed the Speed and Force of our management capabilities. Generally speaking, fuel treatment “optimization” models like this one that considers only a single fire behavior characteristic (rate of spread) should be suspect and careful consideration needs to be taken as to whether the single focused treatment scheme is robust enough for the fuels problem at hand. Analysts should ask if given the mix of fire management resources available, will we be able to control the faster moving, low intensity fire easier than the slower moving, high intensity fire? If the faster low intensity fire is preferable, then a modeling scheme that considers intensity rather than rate of spread should probably be considered.

The design of these simulations use fire spread as the fire behavior variable that measures success, a reduction in which is assumed to be the more favorable outcome. In practical terms, a fuel bed that is characterized by slow moving, high intensity fires that are beyond our ability to control may be a bigger problem than a flashy fuel bed characterized by fast moving, low intensity fires. Care should be taken to insure the right conclusions are drawn for the particular landscape and set of circumstances being evaluated.

JFSP Deliverables and Technology Transfer

Project resulted in two papers in print and two others in press at the time of this report. Results were presented at a conference in 2006. In addition, the fuel treatment optimization model was included in version 3.0 of FlamMap, which does make at least a portion of the results of the study accessible to managers.

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